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The Origins of Metropolitan Transportation Planning
in Travel Demand Forecasting, 1944-1962

A thesis submitted in partial satisfaction
of the requirements for the degree
of Master of Urban and Regional Planning

by

Cheryl Deutsch

2013

ABSTRACT OF THE THESIS

The Origins of Metropolitan Transportation Planning
in Travel Demand Forecasting, 1944-1962

by

Cheryl Deutsch

Master of Urban and Regional Planning

University of California, Los Angeles, 2013

Professor Martin Wachs, Chair

Responding to cities' calls for aid in combating traffic congestion and urban decline, the 1956 Federal-Aid Highway Act and its Highway Trust Fund endowment paved the way for Interstate highways into American cities. As president of the American Municipal Association, Nashville's mayor, Ben West, led the charge for such funds to pay for comprehensive urban planning on a metropolitan scale. As chairman of the National Committee on Urban Transportation, he oversaw unprecedented efforts to promote and disseminate innovation in transportation planning methods – methods that Congress made mandatory for highway funds after 1962 and that remain important today. Based on archival research and interviews with transportation planners of the era, this thesis reconstructs the social, political, intellectual, and technological context out of which metropolitan transportation planning emerged in the 1950s. In doing so, it examines the four-step method of travel demand forecasting as a product of social and municipal reform.

The thesis of Cheryl Deutsch is approved.

Matthew Drennan

Brian D. Taylor

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University of California, Los Angeles

2013

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Preface & Acknowledgements

This thesis is unique in its effort to tell the history of transportation planning through technological innovation and social change as a series of interwoven *stories*. It is my hope that deviating from the standard form of graduate student thesis may make it easier for current practitioners, scholars, and students of transportation planning to relate to those whose work shaped the field during the 1950s. At a time when many metropolitan planning organizations are rethinking the forecasting methods that have shaped transportation planning over the last sixty years – experimenting with alternative activity-based models and microsimulation – and as ever more complex forecasts face increasing skepticism and misunderstanding from both decision-makers and the public, this project offers to illuminate the trials and errors of a previous era of innovation.

In completing this project, I am particularly indebted to the wise guidance of Marty Wachs and the careful reading of Brian Taylor. I also want to thank Mike Smart for introducing me to travel behavior analysis and encouraging me to start this project in the first place.

This thesis would not have been possible – or nearly as enjoyable – without all those who shared their thoughts and experiences with me, including: Tom Deen, Alan Pisarski, Dan Brand, Bill Garrison, Keith Gilbert, Bob Siler, Neal Irwin, Kevin Heanue, Ed Weiner, George Wickstrom, David Boyce, and Lou Thompson. Many of their stories and friends appear in these pages.

My studies and research have been made possible by support from the National Science Foundation, the UCLA Institute for Transportation Studies, and David and Marianna Fisher. Excellent resources at the Institute of Transportation Studies Library of UC Berkeley added meat to the bones of my research.

Thanks especially to my family and friends for supporting me in all of my curious endeavors.

“Since forecasting is a projection of hindsight into the future, it follows that the better the hindsight, the better the ... forecast.”

– *Highway Traffic Estimation* (Schmidt & Campbell, 1956, p.174)

The Three C’s of Metropolitan Transportation Planning

In April 1962, President John F. Kennedy spoke before Congress about the need for comprehensive transportation planning in American cities. Shifting the focus of highway planning from rural connectivity to the interests of urban areas, where an increasing majority of Americans were then living, Kennedy sought to integrate highways within more comprehensive urban planning. “Highways are an instrumental part of any coordinated urban transportation program and must be an integral part of any comprehensive community development plan,” he said. “Accordingly, I have requested the Secretary of Commerce to make his approval of the use of highway planning funds in metropolitan planning studies contingent upon the establishment of a continuing and comprehensive planning process” (The transportation system of our nation, 1962). Later that year, Congress passed the 1962 Federal Aid Highway Act, mandating “continuous, comprehensive, and coordinated” planning in all metropolitan areas with populations over 50,000. The Act made such “3C” planning, as it became known, a requirement for federal funding of highway and transit projects; a requirement that remains important today. Though Metropolitan Planning Organizations (MPOs) were not federally mandated until 1973, the 1962 Act and its 3C requirement institutionalized metropolitan transportation studies, and many MPOs cite the Act on their websites, in their own origins stories.

If Kennedy's speech to Congress was visionary, it was also a response to developments in cities across the country. In the years following World War II, economic growth re-fueled prewar trends in suburbanization. At the same time, Americans, especially across the South, demonstrated increased faith in the public sector and demanded good governance. Cities undertook municipal reforms and metropolitan consolidation in order to shed the corruption of political machines and cope with the strain of suburbanization. The civil rights movement likewise challenged prevailing structures of power. In this context, urban transportation planning began to come of age.

Kennedy's speech was also a response to perceived problems: as auto ownership rose and travel suburbanized, so did congestion. For a decade before Kennedy's call for comprehensive urban transportation planning, it was commonly understood that cities needed better roads and transit infrastructure to remain economically viable and productive. What was perhaps needed most, though, was information with which to comprehend this perceived problem. Neither the decennial Census nor any other government surveys collected information about auto travel. Transportation planning was in its infancy, and what traffic data existed were raw and rudimentary. The few universities that offered graduate degrees in traffic engineering could not graduate students fast enough.

These newly minted traffic engineers began to address the vast chasm then separating the perceived problems of urban transportation and the knowledge that would be necessary to advance solutions to those problems. Often with help from the Bureau of Public Roads – known today as the Federal Highway Administration – they pioneered extensive studies of transportation in the cities in which they worked, conducting home interview surveys and applying new statistical methods and behavioral theory drawn from Sociology in their attempts

to understand urban and suburban travel behavior. They used some of the first computers to analyze data on a scale unheard of before. It was a time of great innovation and bold public initiative; a time of ambition as well as naïveté in striving for comprehensive reform of public sector functions. Through trial and error, these young traffic engineers forged new methods and laid the foundation for transportation planning today. The 1962 Highway Act's mandate of continuing, comprehensive, and coordinated transportation planning was as much a codification of these new methods as a mandate for their universal implementation. The Act was a landmark in the development of regional planning as practiced today. Metropolitan areas that had not done so already quickly acquired the personnel and skills they needed to complete the 3C process and benefit from the Act's offer of federal assistance.

This thesis seeks to reconstruct the context out of which the 3C mandate emerged. Looking back to the context in which the 3C methods of travel demand forecasting developed reveals important shifts in the very meaning of planning, while offering new perspective on the history of the interstate system, metropolitan planning, and urban governance in the years following World War II. This history is interesting not only for its own sake, but in light of continuing discussions about the methods of travel demand forecasting and metropolitan planning in the United States and elsewhere. To the extent that we are still living with the legacy of that era, it is worth remembering why things developed as they did. As William Faulkner wrote, "the past is never dead. It's not even past" (Faulkner, 2012, p.73).

Highways into the Cities

An important precursor to the 3C mandate of 1962 was the Federal-Aid Highway Act of 1956, which established the Interstate Highway System and the Highway Trust Fund to pay for it. Not just rural highways, regional highways, or their urban extensions, to be planned and maintained by the states, the new system of *interstate* highways would connect 90 percent of the country's largest cities (Weiner, 1999). Cities had always had a role in highway planning, but the 1956 Act reflected their increased claim on the resources and opportunities that highways – and their funding – offered. At one time, 'good roads' had started at city limits and extended outward as far as wealthy car owners desired for their pleasure rides into the country. As auto ownership grew, state governments and then the federal government funded increasingly networked, newly paved roads through rural areas. And while the Bureau of Public Roads (BPR) had called for highway planning to include comprehensive urban transportation planning as early as 1944, when it laid the foundation for what would become the Interstate Highway system in *Interregional Highways*, it was not until the 1950s that urban areas staked an organized claim on highway funding. Their buy-in, in terms of Congressional votes, was critical in justifying the entire interstate system.

When the 1956 Act passed, civil engineering had the benefit of decades of state and federal aid in building highways through mostly rural areas. Highway engineers were skilled in the construction of bridges, tunnels, and interchanges, as well as miles of open road paved with bituminous asphalt through even the roughest of terrain. Building highways through densely populated metropolitan areas was another matter altogether, though (Rose & Mohl, 2012, p.x). For decades, Congress justified highway funding in the name of moving farm goods to market.

Implicitly, improved market access was supposed to help stem the tide of rural to urban migration, as sharecroppers and small farmers left rural areas in droves. In the end, the improved access to towns and cities only accelerated this rural exodus.

Cities were not only increasingly populous but also increasingly sprawling and auto-dependent in the postwar years. Much was written about ‘the urban transportation problem’ of congestion. Transit, neglected during the war and suffering financial hardship as well as competition from a growing number of cars on the roads, was seen as inefficient and out of date. Everyone aspired to own a car. In this context, congestion was a liability that fueled suburbanization and contributed to the decline of central cities. And if congestion was at the root of the problem of urban decline, then highways were the solution for urban revival. Well-planned, controlled access highways through and around cities were thought to be the solution to the problem of sprawl and downtown decay. Highway engineers turned to sociology for analysis of human behavior to complement their knowledge of bridges, tunnels, interchanges, and asphalt.

Congestion was not new to the 1950s, but only the most radical commentators at the time saw “the urban transportation problem” in its historical context. In a 1956 publication for the Brookings Institution entitled *The Metropolitan Transportation Problem*, Wilfred Owen (1956) wrote: “The urban transportation problem, although often thought of as relatively new and associated with the automobile and the United States, is both global and historic. ... The big city and its transportation problems were confounding the experts over a century ago, long before the complications of internal combustion” (p.5-6). What was perhaps different in the postwar years was an expectation that such problems could be solved. Technological advance offered the promise of finality and absolution and, in this, Owen was also a believer. His proposed solution to the problem of urban congestion was comprehensive urban planning: “In a nation that is both

motorized and urbanized, there will have to be a closer relation between transportation and urban development,” he wrote. “We will have to use transportation resources to achieve better communities and community planning techniques to achieve better transportation. The combination could launch a revolutionary attack on urban congestion that is long overdue” (Owen, 1956, p.266). While Owen’s call for revolution may have been a voice in the wilderness, he was not the only one calling for change. It is unlikely that comprehensive planning and research would have ever inspired the public imagination, the attention of Congress, or the stream of federal funds that the interstate highway system did. Comprehensive land use and transportation planning evolved only as necessary components of that interstate system. Comprehensive urban planning as practiced today is a byproduct of the Interstate Highway System; set in motion by the 1956 Highway Act and its deference to shortchanged cities.

Before 1956, transportation planning was piecemeal and highway construction somewhat uncertain. Congress, still wary of investing so much in infrastructure that was not necessarily within the purview of the federal government, had to renew funding for the Federal-Aid Highway Act every year or so. Fiscal conservatism ruled the day, and the Constitution did not explicitly authorize the federal government to collect tolls for road construction and operation. In 1954 Congress was still reluctant to create a guaranteed source of federal funding for highway construction, and a more ambitious Highway reauthorization bill died in committee. Early the next year, Tennessee Senator Al Gore Senior revived the bill and organized hearings on what ultimately became the 1956 Act. In the end, it was the organized interests of cities that tipped the balance toward sustained highway funding and made the case for a larger portion of federal highway aid to go to urban areas. Among those who spoke at the hearings was Nashville mayor Ben West. Testifying on behalf of the American Municipal Association, which represented

cities across the country, West said: "cities alone or together in partnership with State highway programs can no longer cope with expanding traffic demands" (Weingroff, nd). West himself had ambitions for his own city of Nashville, and he was convinced that cities across Tennessee were not getting a fair deal vis-à-vis rural areas.

Nashville's development in the postwar years – neither typical nor entirely unique among American cities of the time – serves to paint a picture of municipal and social reform that was crucial in the development of transportation planning on a metropolitan scale. Methods of travel demand forecasting grew out of new ways of thinking about cities as complex, metropolitan areas. Such new thinking emerged in a context of urban change: new patterns of residence, shopping, consumption, automobility and social mobility posed problems greater than just traffic congestion in cities like Nashville. Attempts to cope with such change in Nashville therefore offer to illustrate the context out of which metropolitan transportation planning emerged, as well as to motivate the influential advocacy work of Ben West, who played such a significant role in federal highway policy.

Hired as a young traffic engineer for the city of Nashville in 1956, Tom Deen remembers multi-lane state highways narrowing into city streets at the municipal limit (personal communication, March 1, 2013). In *The Metropolitan Transportation Problem*, Owen (1956) paints a similar picture of failing road infrastructure: "The modern highway in open rural areas," he wrote, "often degenerates at the city limits to an obsolete right-of-way crowded on both sides with commercial activities strung out in unsightly array" (p.3). Mayor West, like mayors across the country, was concerned that state highway officials only cared about building highways between cities. He feared that upgrading the state routes into national highways would dump more regional traffic onto an already congested city grid. West saw the Interstate system, with

90 percent federal funding for which he and other mayors were advocating, as an opportunity to solve many of Nashville's problems. He had been elected mayor on a wave of municipal reform. A forward-thinking mayor in a city suffering from un-planned growth, he knew all too well how desperately cities like his needed federal assistance in planning, and highways offered a particularly lucrative avenue for that financial aid.

Suburbanization and Metropolitan Integration in Nashville

West was one of the country's most influential advocates for urban and transportation planning before he lost political favor in Nashville for taxing cars' use of city streets, among other attempts to keep Nashville financially viable in the face of suburbanization. In the 1940s, Nashville was stuck. Tennessee did not have municipal home rule, so Nashville lacked the ability to advocate for itself at the state level. Instead, the city was legislatively submerged in Davidson County, whose suburbs were home to an increasing proportion of Nashville's residents and retail establishments, even as most of the city's jobs remained downtown. Without home rule, Nashville was subject to rural politics dominant in the state legislature; politics that did not favor cities or their increasing proportion of black residents newly enfranchised by elimination of the poll tax. In 1940, the city of Nashville had 65 percent of Davidson County's population but only 41 percent of representatives on the County Court (Spinney, 1990, p.88). The County Court, in turn, determined the County's delegation to the state legislature and ultimately controlled the fate of the city. The suburbanization of Nashville's population was winnowing away at the city's tax base even while the County as a whole could not afford to provide services to suburban residents. Nashville's struggle to cope with suburbanization and increased motorization offers insight into the problems of urban areas to which newly emerging

metropolitan planning offered a solution. Ben West saw the state's disregard for urban problems as a threat to the city's future.

Suburbanization was not new to Nashville or most American cities in the postwar era. The popularity of automobiles, along with the extension of streetcar lines, had fueled suburbanization in the 1920s, but suburban expansion had slowed during the Depression and subsequent war. After the war, an urban housing shortage accelerated a suburban development boom (Brownwell, 1990, p.1). Nashville's existing housing shortage became critical: tens of thousands of veterans returned to the city, looking for homes for their families and unable to find them. The Nashville Housing Authority, a legacy of the New Deal that had never been well-received in Nashville, stepped in with federal aid money to help solve the housing crunch and simultaneously turned the tide in public opinion of local government (Spinney, 1990, p.105). Following the war, according to one Nashville historian, "nearly all discussions of city government turned to City Hall's impotence and the county delegation's ability to hamstring city policy making" (Spinney, 1990, p.90). Fed up with the political status quo, veterans demanded increased services and more efficiency in government, organizing passage of a new city charter in 1947 to establish a single, powerful mayor (Bernard, 1990; Spinney, 1990). One of the city's first major efforts after this municipal reform was to improve two-thirds of the city's streets.

If Nashville's infrastructure was crumbling, though, city resources had never been distributed equally among residents, and an empowered mayor was still up against a lot in the trend toward urban decline. Suburbanization was fueled by an urban housing shortage, but it was also an instance of white flight. Segregation defined not only education, employment, and use of public facilities, but residential location and social life, as well, and Nashville's black neighborhoods had always lagged behind their white counterparts in receiving infrastructure

improvements. After World War II, though, with the city perhaps more spatially segregated than ever, both black city residents and white suburbanites began to demand more from local government.

In 1946 Nashville voters approved a plan to raze the city's black business district in order to widen boulevards and construct an auditorium. The effort also forced the black community to confront its own weak voting power. In the end, changes to federal housing legislation that supported urban renewal doomed the project, and the black business district was saved (Spinney, 1990, p.64). Still, the threat of having their community razed motivated black residents of Nashville to organize for greater voting power. In 1951, they helped Ben West barely defeat his more conservative opponent in the mayoral race. Tom Deen (personal communication, March 1, 2013) remembers West as a short, round, cigar-smoking, good ol' boy Tennessean. He had a big voice and an even bigger Southern accent. The day Deen arrived in Nashville to interview for his job in the traffic engineering department (he would be the second staff person), his soon-to-be boss took him over to City Hall to meet the mayor. West was not in his office, though; He was out on a street corner having his picture taken for one of the local newspapers, touting the new streetlights he was having installed across the city. West was also a friend of Nashville's black community. As far as West was concerned, what was good for black residents was good for the city, and what was good for Nashville was good for its black residents.

In 1949, as vice-mayor of the city, West was the first white politician to address Charles Spurgeon Johnson's Race Relations Institute at Nashville's Fisk University. Addressing the gathering of prominent black academics and community members at their annual meeting to discuss the state of race relations in the South, West spoke about the need for equality in welfare as well as public services: "not only food, shelter, and clothing but equal ... educational, cultural,

and governmental benefits” (in Spinney, 1990, p.96). Two years later, as a state Senator, West sponsored legislation to reform Nashville’s City Council, abandoning election-at-large, which concentrated all of the city’s elected Council members in one, wealthy white neighborhood, for election-by-ward. In the first election under the new system, two black men were elected to the City Council, one of whom, endorsed by West, upset his white opponent (Spinney, 1990, p.96).

While better off, in most regards, than the black neighborhoods of Nashville, the suburbs of Davidson County were no paradise. The County was dependent on the city for both jobs and services, such as water. Suburban housing had been built in haste to meet postwar demand and in spite of the city’s political paralysis, but without sewers, which were difficult and costly to dig. Instead, suburban homes were built with septic tanks unfit for the soil of central Tennessee that overflowed with rain and polluted the water supply, raising public health concerns.

Similarly, the suburbs lacked public fire and police protection, as well as garbage collection and street lighting. Private companies stepped in to provide such services, but they did so unevenly. “In every way, the system was costly, inefficient, and potentially dangerous to the health and safety of the entire community,” writes Don Doyle, in his history of Nashville. “The shoddy, incomplete services available to suburban Nashville were detrimental not simply to the residents but to the corporate vitality of the whole metropolitan community” (Doyle, 1985, p.194).

Nashville and cities like it had the benefit of learning from the experience of more (sub)urbanized Northern cities. The city’s civic elite were downtown department store owners and others with a vested interest in preserving the vitality of the city; they saw the impact of suburbanization on their business and sought to correct the suburbanization trend with better, more comprehensive governance and planning. The same year that West was elected mayor, the city’s business community published *A Future for Nashville*, responding to the city’s suburban

trouble with calls for comprehensive metropolitan planning and the consolidation of the City of Nashville and Davidson County. Further decentralization was simply unsustainable, and Ben West was a force of both metropolitan consolidation and social integration. The push for metropolitan consolidation to solve the problems of the city's declining tax base and the suburbs' need for sewers and other services culminated in 1956 in the publication of a *Plan for Metropolitan Government*. Prepared by a team of city planners and political scientists, the plan called for comprehensive municipal reform over piecemeal policy to address Nashville's growing problems, and Ben West became a champion of metropolitan government and planning in Nashville and across the country. He wanted Nashville to be an example to cities elsewhere (Deen, personal communication, October 20, 2012). At about the same time, the black community pushed for school integration, in the wake of *Brown v. Board*. Calls for integration of city and county existed simultaneously with efforts to integrate Nashville society. Both efforts took years to progress. In 1958, when the consolidated Metro plan came up for a referendum vote, it failed. Pro-Metro advocates failed to make their appeals widespread or populist, while the black community opposed it for fear of losing their voting power. A last minute anti-Metro effort appealed to provincial and anti-government interests, further tipping the balance against consolidation (Doyle, 1985, p.203).

After the Metro effort failed, West became increasingly determined – if not desperate – to ensure the city's financial viability. Among the more heavy-handed measures to which he turned was a wheel tax. In August 1959, he pushed the City Council to levy a \$10 wheel tax on every vehicle that used city streets for thirty days or more in a year. The law was hard to enforce, though, and suburbanites balked at such “taxation without representation.” When those who had paid the tax raised a row about its lack of enforcement, the City had the owners of offending

vehicles arrested and forced to pay a \$50 fine. West further alienated suburbanites with the forced annexation of some wealthy suburban communities (Doyle, 1985, p.191).

It was in this context that West had gone to Washington to lobby on behalf of the American Municipal Association (AMA) for urban highway funding. Convincing Congress to pass the 1956 Highway Act and create the Highway Trust Fund was an achievement for Nashville as for all cities, but such federal aid was a stopgap measure rather than a permanent solution to declining city tax bases and strained infrastructure. West also turned his attention to the unequal distribution of state resources, which favored rural areas. Despite the Tennessee state Constitution's requirement for legislative redistricting on a regular basis, the state legislature had failed to do so since the turn of the century. Consequently, state legislative representation was "malapportioned," and cities were being starved of state resources. Until 1959, the fiery West had managed to restrain himself from attacking the state legislature, for fear of repercussions, but by 1959, he couldn't take it any longer. Douglas Smith (2010), writing about the myth of Southern exceptionalism and the national fight against malapportionment across the country, writes that West "had ceased to disguise his animosity for the Tennessee legislature. Certainly he did himself and his constituents no favors when, as president of the American Municipal Association, he highlighted the problems of malapportionment in a series of speeches with charts showing how the pigs and cows in rural Moore County were much better represented than the people of Nashville and Davidson County" (p.271). The lawsuit went on to the Supreme Court, which decided in favor of the cities and re-apportionment in 1962. Chief Justice Earl Warren later called the case, *Baker v. Carr*, the most important decision of his tenure on the Court.

If city-county consolidation felt irreparably stalled, though, the proponents of racial integration in Nashville were gaining confidence. By 1960, Nashville's suburban population exceeded that of the city, while black residents made up 43 percent of the city's population (Doyle, 1985, p.228). On February 13, student activists sat down at department store lunch counters downtown in solidarity with Greensboro, North Carolina civil rights activists, igniting a months-long protest of segregation in the city. The hundreds of student activists who started the protest had been preparing for such a moment for months and some for years. Reverend James Lawson had come to Nashville in 1956 to attend divinity school but also to organize a movement to end segregation. He, in consultation with other national civil rights leaders, had chosen Nashville strategically: located in a border state with progressive city leaders and a poorly organized segregationist element, Nashville also had a relatively large black middle class and several black universities and colleges. The sit-ins were inspired, in part, by the frustration of black patrons, who made up an increasingly large percentage of downtown department stores' customers and yet couldn't eat at their in-store lunch counters.

As the students continued their sit in day after day, enduring the abuse of white toughs and police apathy, the broader black community organized to boycott all of the downtown department stores. As the boycott wore away at these downtown merchants dependent on black business, it was segregationist violence that ultimately tipped the balance toward desegregation. In April, white supremacists bombed the home of Z. Alexander Looby, a prominent black lawyer, and student activists responded by marching in the thousands to the state courthouse, where Ben West met them on the courthouse steps. There, Diane Nash, a Fisk student, pressured him to take a stand (Doyle, 1985, p.249; Halberstam, 1998). In his time as mayor, West had put up new street lighting, new street signs, and had built libraries in the city. He had also

encouraged the hiring of more black police officers and fire fighters, had integrated the airport restaurant, as well as city golf courses, and had appointed a black lawyer, Coyness Ennix, to the Board of Education (Doyle, 1985, 228). Calling for the desegregation of privately owned restaurants was a political move of another order, though. Standing on the courthouse steps in front of thousands of black students, community members, and their white allies, Ben West agreed to support the students' call for integration of city lunch counters. Nashville became the first southern city to do so.

The year 1962 marked the culmination of at least a decade and a half of efforts to make government more forward thinking. In that year, the Supreme Court's decision in *Baker v. Carr* decided in favor of Tennessee cities and reapportionment, President Kennedy called for federal highway funding to require comprehensive urban

transportation planning, and voters in Nashville and Davidson County approved a referendum to consolidate city and county into one metropolitan government. This second Metro effort was much more grassroots than the first, including the black community that had opposed the first referendum. The pro-Metro campaign also played on suburbanites' distaste for West's annexation efforts, and he came to see the entire effort – a cause he had championed at every level of government – as a threat to his own considerable political power. Joining with segregationists and states' rights proponents in an unlikely, and unsuccessful, alliance to oppose

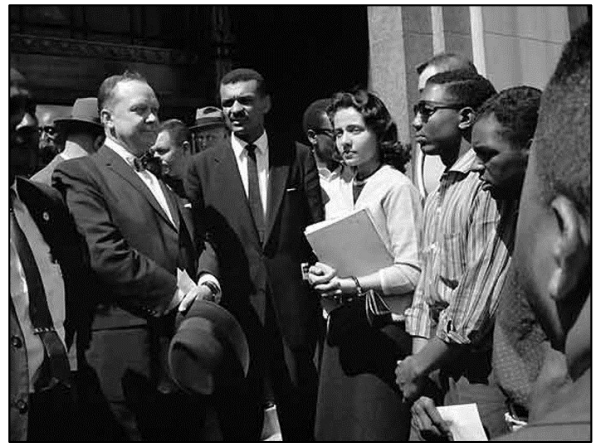


Image 1: Diane Nash and other civil rights activists confront Nashville Mayor Ben West, where he called for the desegregation of lunch counters (photo courtesy: <http://www.freedommosaic.com>)

the referendum, West refused to run for mayor of the newly formed metropolitan government, and so ended his political career.

The new metro government was inaugurated in 1963 and became a model of reform along with other urban areas, such as Miami-Dade, Florida. “Many were convinced that the coming of metropolitan government meant a whole new era of economic growth, downtown revitalization, and general improvement in the quality of urban life,” writes Doyle, in his history of Nashville (1985, p.215). “For the generation of World War II veterans and others who came of political age in the 1950s, Metro’s triumph confirmed their faith in the value of *cooperation* among politicians, business leaders, professional planners, and academics.” Slowly, Metro extended sewers and other services to the suburbs. In 1963 it appointed a committee to facilitate further integration of public accommodations. In the years to come, metropolitan consolidation would prove to be an important pipeline for receiving federal funding. Despite years of tension and of change, as well as a persistent feeling of not living up to their potential, the forces of consolidation and integration had both made significant progress in the face of decades-long opposition. The story of Nashville’s metropolitan integration serves to illustrate many of the issues that urban areas were grappling with in the 1950s, as well as their effort to address those issues. The changing demographics of retail and residential demographics inspired civil rights activists and traffic engineers alike. Transportation planning did not emerge in a vacuum but in a politically charged and socially dynamic context. Influential figures like Ben West and John Kennedy grappled with all of these issues simultaneously, and while traffic congestion was not the most pressing concern in Nashville at the time, recounting the city’s rich history sheds some light on how urban highways seemed to offer an easy solution to the many problems associated with suburbanization.

Better Transportation in Your City

In his history of the Interstate Highway System, Tom Lewis (1997) argues that mayors had struck a Faustian bargain with the 1956 Highway Act; selling the souls of their cities for the short-term boost of highway construction (p.152-3). If this is true, then mayors also joined together with planners, engineers, and other municipal officials, academics, and policy-makers to try to turn highway funding into something more than just cold concrete. Tom Deen, the young traffic engineer hired in Nashville in 1956, remembers taking a trip to Washington with Ben West, who shared his true feelings for Washington politics on the flight home (personal communication, March 1, 2013). On the trip, West introduced Deen to many of the important players in national transportation advocacy. He was there to make things happen for Nashville and the other cities he represented as president of the American Municipal Association (AMA). As the plane took off from National airport to return to Nashville, West looked out over Washington and saw the city's lights beginning to flicker against a setting sun. Turning to Deen, he said, "Tom, you see that city out there? Tom, when the good Lord gets ready to give this earth an enema, that's the place he's going to stick the tube." Pointing out at the city of Washington, he told Deen, "Nashville's not as big a city as that, but it's a great city." Before his political career in Nashville ran out, and despite his apparent distaste for national politics, West worked with an unprecedented array of urban interests to shape federal highway finance into something more practical for the country's urban areas.

One of the groups West introduced Deen to on that trip was the Automotive Safety Foundation. Funded by automobile manufacturers and their related industries, the Auto Safety Foundation worked with state highway departments between 1947 and 1955 to plan urban extensions of the highway system, completing highway needs studies for state legislative review

(Weiner, 1999, p.27). Alan Voorhees was a prominent voice of the Foundation in the 1950s, when it began work to create a National Committee on Urban Transportation. Voorhees had been a city planner in Colorado Springs before completing a one-year Masters degree newly offered by the Yale Bureau of Highway Traffic. As one of his later colleagues would say of him, “Al’s strength was first of all his intellect. You respected that. And his other strength was pulling together the right people” (K. Gilbert, personal communication, March 7, 2013). With the Auto Safety Foundation, Voorhees helped bring together representatives of “virtually every association concerned with transportation in the urban area,” according to E. H. “Ted” Holmes (1973, p.383), who was deputy commissioner of the Bureau of Public Roads (BPR) at the time. Ben West became the first chairman of the National Committee on Urban Transportation in 1954.

The National Committee’s first major undertaking was to produce a series of manuals with which urban areas would be able to carry out their own comprehensive transportation studies. The two year effort utilized nearly 150 experts in various areas of transportation and concluded with the publication of a book called *Better Transportation in Your City*, which served to orient politicians and engineers alike to the exercises and techniques outlined in its corresponding seventeen procedural manuals (Holmes, 1973, p.383). Together, the *Better Transportation* guide and manuals covered topics such as: improving transportation administration, modernizing laws and ordinances, conducting home interview origin-destination surveys, measuring existing street services and facilities, measuring traffic volumes, conducting parking studies, maintaining accident records, measuring transit service, financial records and reports, cost accounting for streets and highways, and developing project priorities for transportation improvements, among others. “This tremendous volunteer effort,” writes Ted

Holmes (1973, p.383), who was one of the project consultants, “not only produced technical documents of lasting importance but sparked a significant gain in federal-state-local relationships and opened a channel for federal aid to cities in solving their local transportation problems.” *Solving* might be a bit of an overstatement, but the National Committee manuals certainly pulled together the best minds of the day.

In addition to Ben West and Al Voorhees, Phil Hammer, O. W. Campbell, Doug Carroll, Wilbur Smith, and Norman Kennedy were directly involved in *Better Transportation*. Phil Hammer had written an influential report on school integration with Harry Ashmore in 1954. He also directed Atlanta’s Metropolitan Planning Commission, established in 1947 with the consolidation of planning functions in DeKalb and Fulton Counties, as well as the City of Atlanta. It was the country’s first multi-county planning agency. He later founded Hammer and Associates, an urban economics firm; taught planning at Georgia Tech; and advised the Kennedy Administration in its transition. O. W. Campbell was the city manager of San Diego and represented the International City Managers’ Association. He would later become city manager of the consolidated Miami-Dade County. Doug Carroll received one of the first PhD’s in urban planning from Harvard, where he studied under the modernist architect, Walter Gropius. Carroll also pioneered new methods in urban transportation research in the Detroit Metropolitan Area Transportation Study. Wilbur Smith had been a pioneer in early origin and destination studies and taught at Yale, while Norman Kennedy was a professor at the Institute of Transportation and Traffic Engineering, at the University of California, Berkeley. Other participating organizations and institutions included the Brookings Institution, the Eno Foundation, the Highway Research Board, the Bureau of Public Roads, the American Association of State Highway Officials, the American Society of Planning Officials, and the Municipal Finance Officers’ Association. *Better*

Transportation in Your City emphasized comprehensive transportation planning, including systematic data collection and analysis for better informed decision-making. The guidebook, sounding a note very similar to that of Wilfred Owen in *The Metropolitan Transportation Problem* (he was also a consultant on the project), states that “transportation is only a segment of the over-all urban picture and must be considered as a part of the broad problem of urban development” (National Committee, 1956, np).

The guide and manuals also strove to be user-friendly and accessible; to make transportation planning easy and affordable. “Set forth herein,” begins *Better Transportation*, “is the basis for a practical transportation planning program, continuous in nature and more comprehensive than generally undertaken heretofore – yet one that is economically feasible and can be easily carried out by a city with its own staff. The program provides for the systematic collection of facts about all aspects of the transportation system, and the evaluation of these facts against basic standards to guide in planning, providing and operating an effective, properly integrated system” (National Committee, 1956, p.1). The book also calls for planning on a metropolitan-wide basis since “the problem cannot be circumscribed by municipal boundaries” (National Committee, 1956, p.3).

The book introduces politicians and engineers un-trained in transportation to the basics of research then being carried out. Why do people travel? Why do they go to the places they do, and why do they choose the modes of transportation and the routes that they do? How can current travel patterns be simulated and futures patterns forecast? These are the kinds of questions that researchers were asking at the time. Transportation studies sought not only to understand but to be able to predict, and therefore plan for, urban residents’ travel. The *Better Transportation* guide draws conclusions from leading research, explaining that the relational

nature of travel necessitates holistic study and thinking: “Traffic movements in an urban area are related to the interplay between land uses. An individual land use by itself does not produce trips. For example, a shopping area in the wilderness would not generate trips, but a center adjacent to a residential area will develop trips. Therefore, in considering traffic movement in an urban area, it must be recognized that travel is affected by the interrelationship between land uses” (National Committee, 1956, p.1).

Such thinking had begun to change the way engineers understood cities. New statistical methods and studies in Sociology revealed human behavior to be ordered, if still elusive. Ultimately, the guide sought to equip engineers with techniques for carrying out metropolitan-wide transportation studies of traffic. They sought to convert that data into forecasts. The guide laments the fact, however, that “techniques for projecting traffic data are still in their infancy” (National Committee, 1956, np). The best that planners could do would be systematic, thoughtful study of trip-making patterns throughout a metropolitan area and a logical forecast of future growth in such trip-making.

If *Better Transportation* was somewhat vague about forecasting methods, it was also naïve about the planning process more broadly and the role of plans and community input in decision-making processes. It promised to produce better-informed plans through research and alternatives testing. These alternatives could then be presented to the public. Plans could be prepared according to local needs and contexts, emphasizing transit here or auto usage there, with careful analysis of each plan’s costs and benefits. “These plans could then be presented for the intelligent consideration of the public. Utilization of the fact-gathering program outlined in this manual will guide cities in the development of realistic plans to overcome their transportation problems. When the facts are presented properly, legislative bodies and the public

can make the decisions required” (National Committee, 1956, p.4). In this way, it underestimated the difficulty of reconciling often irreconcilable community interests.

The first draft of *Better Transportation in Your City* was finished in February 1956. In its research-driven and comprehensive approach to transportation planning on a metropolitan scale, the guide offers a stark contrast to the image of urban highways hastily drawn by state highway departments and the BPR for the infamous Yellow Book; infamous because it is credited with swaying members of Congress representing urban areas to support the 1956 Act and the Highway Trust Fund. That both the Yellow Book and *Better Transportation* existed simultaneously – each relying on input from the BPR – suggests that the historical significance of the Yellow Book has perhaps been

overstated. As the case of Nashville and Ben West’s role in advocacy for the 1956 Act

illustrates, cities had more at stake in advocating for highway funds than simply pork barrel politics. One month after the first draft of *Better Transportation* was completed, O. W. Campbell volunteered San Diego as the project’s pilot city. Like Nashville, San Diego’s city charter was a product of recent reforms. It had nonpartisan councilmen, no mayor, and an appointed city manager (Bridges, 1990, p.105, 87). Keith Gilbert, a young engineer who worked on the San Diego pilot study, remembers the project fondly: “We were lucky in San Diego, because we had a forward-thinking city government to get us started,” he said (personal communication, March 7, 2013). The pilot study sought to evaluate the proceedings outlined by



Image 2: Yellow Book map of Interstate Highways through Nashville (courtesy: <http://commons.wikimedia.org>)

the National Committee manuals. The cover of its 1957 study report is decorated with the outline of San Diego County as a background. In the upper right-hand corner is a blue circle: a southern California sun, presumably. Superimposed over the blue sun are several images depicting means of transportation both old and new. There is a large cruise ship overtaking a smaller, darker multi-masted sailing vessel, while a sleek airplane overtakes a small, dark prop, and an aerodynamic bus outruns a horse drawn carriage. An electric train overtakes a coal-fired locomotive, while an automobile speeds past a man on horseback, and a tractor trailer overtakes an oxcart. Clearly, the study was thought to mark a turning point in how the city understood itself. New knowledge, scientifically wrought, offered to move San Diego into the future. In order to get to that future, though, new methods would be required, and not everyone was so comfortable thinking in such a future-oriented way.

Gilbert remembers the resistance of San Diego's city planners, for example. "We called them the colored pencil pushers, and we had to pull them kicking and screaming, because they were reluctant to put down on paper any forecasts of future land uses" (personal

communication, March 7, 2013). Despite the city planners' discomfort, the San Diego project was incredibly cooperative. O. W. Campbell had put together an informal group of city officials from all of the metropolitan region's cities, as well as officials of the state division of highways. They met monthly to stay abreast of study developments and continued to meet even after the study was finished. In the 1970s, the informal group would become an official Metropolitan Planning Organization. In a letter to Ben West sent with the final pilot city report, the San Diego

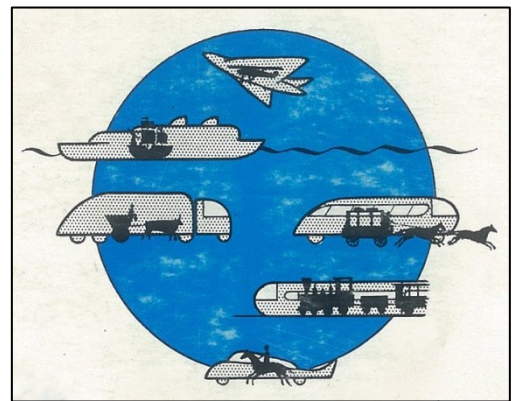


Image 3: Transportation of the future in San Diego (printed on the cover of San Diego Metropolitan Area Transportation Study, 1957)

city manager remarked upon the benefits of the study to the city and concluded: “Perhaps the most gratifying benefit is the spirit of cooperation that has permeated this program” (San Diego, 1957, np). Reflecting on it, Gilbert said, “You can put together all the organizational charts you want, but it comes down to the personalities involved. And it worked in San Diego. It worked really well” (personal communication, March 7, 2013).

The San Diego study followed the National Committee’s lead with a review of administrative structure, laws and ordinances, and finances with regard to transportation. The bulk of the study consisted of collecting data on travel patterns, existing street service, and transit ridership, as well as estimating future travel. Based on these inventories and estimates, the study recommended standards and highway plans.

In the midst of the pilot study, Ben West sent Tom Deen to San Diego to learn from their experience (T. Deen, personal communication, March 1, 2013). He came back feeling overwhelmed by the scale and complexity of what they were doing, and he was more than a bit doubtful about his own ability to carry out such a study in Nashville. Deen had graduated from the Yale Bureau of Highway Traffic in 1956, just as the Federal-Aid Highway Act increased demand for engineers with his training. He chose to work in Nashville because his wife had grown up there and it was close to his home state of Kentucky. At the time, there were very few universities with programs in urban planning or transportation engineering. Yale, Harvard, MIT, Northwestern, UNC Chapel Hill, and Berkeley were among the few that did. A magazine published by the California Division of Highways in 1956 highlights the increased demand for highway engineers, pointing out that the 1954 class of civil engineers nationwide was 3,600, out of which 700 went into highway engineering. State highway departments claimed they needed 4,000 more (McCoy, 1956, p.3-4). Nashville was also uniquely positioned to be affected by the

Interstate highways. The city happened to be at the intersection of six legs of the Interstate system. Remembers Deen: “That was enormous. It was the most of any city other than Indianapolis, and Nashville wasn’t that big of a town” (personal communication, October, 20, 2012). In spite of his training and good luck, Deen felt unprepared for the task Ben West had set for him. National Committee manuals in hand, though, he went about his work. His first priority was to forecast travel on the planned Interstate highways, but he also carried out safety inventories at major intersections, kept accident records, and oversaw construction of bus shelters. What the National Committee guide and manuals offered was “a systematic approach to the whole planning process,” says Deen, “and it was a big leap ahead” (personal communication, October, 20, 2012). In carrying out the Nashville Area Transportation Study, Deen worked with both city and county planning commissions, just as West was promoting the idea of metropolitan consolidation. Deen left Nashville shortly after the failed Metro referendum, but his involvement in transportation planning opened pathways of metropolitan cooperation that would find formal realization in a consolidated Metro government after 1962.

In all of its efforts, the National Committee on Urban Transportation was making the case for planning itself: for future-oriented research and reasoned appraisal of multiple alternatives. San Diego and Nashville are just two examples of the many cities carrying out comprehensive transportation studies at the time. The National Committee’s work, which influenced so many of those studies, is also unmistakably evident in the language of Kennedy’s 1962 speech before Congress. He would have had ample opportunity to interact with the charismatic West, and his framing of urban issues on the national stage bear striking resemblance to the advocacy efforts of West in Nashville and more broadly, through the American Municipal Association (AMA) and the National Committee. At the American Municipal Congress of 1959, held in Denver, West

promoted the National Committee's new publication by giving an address of the same name: "Better Transportation in Your City." Two other speakers at the Congress were then-Senator from Massachusetts John F. Kennedy and Vice President Richard Nixon. The previous year, Kennedy had spoken at a Democratic Party banquet in Nashville. A year after their meeting in Denver, as he prepared to run for president, and in order to appeal to disgruntled urban voters, Kennedy wrote an article for the New York Times Magazine about malapportionment.

From Origins and Destinations to Forecasting

Better Transportation in Your City made accessible to policy-makers and engineers the sum of more than a decade of research and technical development in the field of urban transportation. Until the 1940s, research was conspicuously absent from road construction and traffic engineering. Transit agencies, such as rail, streetcar, and bus operators had plenty of data with which to analyze their services and profitability, but methods of data collection and analysis of travel by private automobile had to be invented. The 1934 Federal-Aid Highway Act was the first federal highway bill to allow funds to be used for transportation research; as much as 1.5 percent of the funds to states. Holmes (1973) cites this Act, with its funding for research, as the progenitor of transportation planning: the marriage of traffic and highway engineering with city planning and social science. As early as the 1920s, Boston and Cleveland had carried out transportation studies that also made rudimentary attempts to predict future travel patterns, but the pursuit of a systematic and scientific understanding of urban travel behavior emerged on the heels of World War II. The 1950s was a decade of experimentation in methods to achieve such a science of the city and its traffic, but by 1962, those 3C methods – much improved – would be compulsory for federal highway funding.

As private automobiles transitioned from wealthy pleasure vehicles to a staple of everyday urban living and middle class life, cities began to collect data on auto traffic. By the 1940s, “origin and destination” surveys were common in the country’s larger cities. Traffic engineers (at the time self-taught and self-named) counted cars and stopped samples of drivers on the road to ask them the origin and destination of their trip. They also surveyed workers at large factories and firms to understand the origins of their work trips. The engineers then began to incorporate data from such origin and destination (O-D) surveys into planning infrastructure improvements. It is not surprising that Detroit, the birthplace of so many of America’s automobiles, was also a leader in the innovation of new traffic analysis techniques. In 1942, Detroit traffic engineers surveyed workers in ten important industrial areas and the central

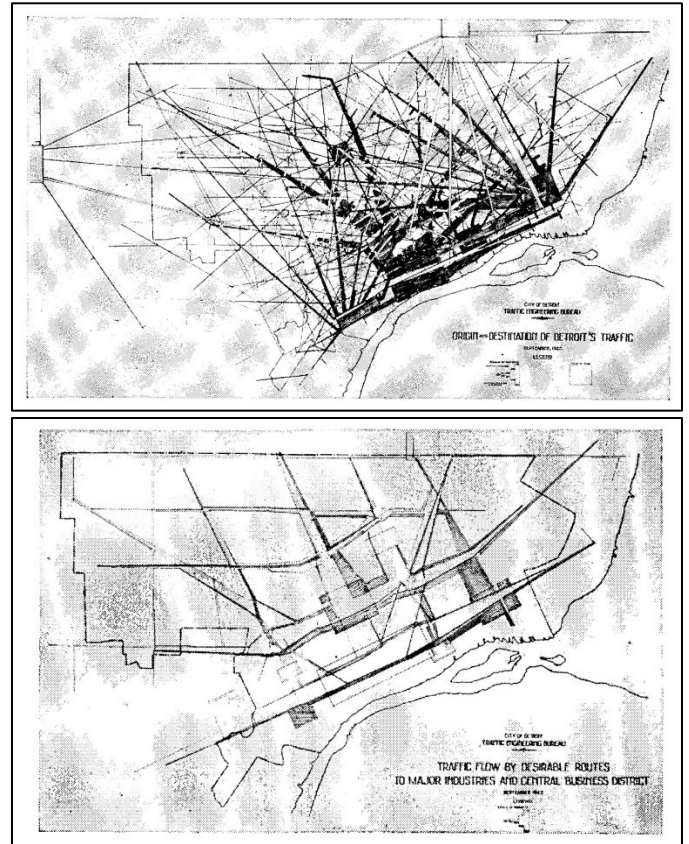


Image 4: Desire line charts from Detroit, 1942
(printed in McLachlan & Lynch, 1950, p.365).

business district about their trip-making habits to and from work. To visualize these O-D data, they developed the first “desire line” charts: having organized O-D data by a grid of analysis zones layered onto a map of the city, including the ten industrial zones and the central business district, engineers connected origin zones with destination zones, widening the connecting lines according to the magnitude of trips between zones. With this first attempt to visualize travel patterns, Detroit engineers proposed highway routes to approximate the greatest lines of desire (McLachlan & Lynch, 1950).

The Bureau of Public Roads' publication of *Conducting a Home Interview Origin-Destination Survey* in 1944 expanded on the techniques used in Detroit and set the standard in travel survey methods. O-D surveys by home interview consisted of establishing an external cordon line (the outer limits of the study area), dividing the study area into numbered zones for analysis, doing external cordon counts to understand vehicles entering and leaving the urban area, as well as home interviews to understand where trips were made and by what mode within the study area. O-D surveys also included trucks, taxis, and transit data collected from transit agencies. Where the home interview really improved on previous O-D methods, though, was in its attention to the socioeconomic motivations for travel, including car ownership, shopping and work habits, race, gender, family size, and employment. Kevin Heanue, now retired from a career in the Bureau of Public Roads and later Federal Highway Administration, remembers conducting one hundred home interviews in Hartford, Connecticut as a young transportation engineer (personal communication, January 17, 2013). The experience of knocking on people's doors and talking to them about their trips the previous day was invaluable, he says. One woman told him: "The only place I went yesterday was to the church and the cemetery to bury my sister." Another survey respondent was a truck driver who'd made forty trips the previous day. Home interview surveys offered a window into the travel behavior of urban residents. According to the BPR, Tulsa, Oklahoma was the first city to conduct an O-D survey by the home interview method (Bureau of Public Roads, 1954). The Bureau's 1944 manual was later incorporated into the National Committee's series of procedural manuals, and the home interview became ubiquitous in metropolitan transportation studies. By 1954, the BPR estimated that more than one hundred metropolitan areas had carried out O-D surveys based on home interviews (Bureau

of Public Roads, 1954). By 1963, the number had grown to 149 cities, out of 216 that would be covered by the 1962 act (Bureau of Public Roads, 1963).

The city of San Juan, Puerto Rico was the first city to report on its efforts to forecast future travel according to land use traffic “generators;” the relationships of land use and travel later described in *Better Transportation*. Based on O-D data collected in 1948, San Juan’s traffic engineers projected a 126 percent increase in traffic across the city by 1970. In order to more realistically map such growth onto the city’s future development, the city’s engineers “decided to correlate the present traffic-generating characteristics of various land uses with the estimated land use and population distribution for the area in 1970” (Carrill, 1952, p.387). San Juan had the benefit of a well-organized Planning, Urbanizing, and Zoning Board, which provided population growth estimates and land use projections to the city’s traffic engineers. Their forecasts included important traffic generators such as port facilities, an international airport, government center, and estimated increases in commercial floorspace of the central business district (Carrill, 1952, p.388). The forecasting procedure itself consisted of estimating total trips by vehicle type for 1970, adding a factor to each current trip to account for that growth, and incorporating other factors to adjust the “distribution” of trips among zones, including the special traffic generators (Carrill, 1952, p.388). This last adjustment was necessary to correct for the fact that applying initial growth factors would assume trips in 1970 to be going to the same places as in 1948, and the engineers chose not to assume that “present service centers will all grow in the same ratio” (Carrill, 1952, p.401). Rather, they assumed that commercial and industrial facilities would redistribute themselves throughout the metropolitan area over the course of twenty years. “In order to have a more rational trip distribution, trips having origin or destination in these centers were reassigned” (Carrill, 1952, p.401). For the proposed airport, as

a special traffic generator, San Juan's engineers studied BPR findings from fourteen other urban airports in the country.

Distributing forecasted origins and destinations among land uses in the city was not the same as routing predicted trips through the road network, though. To visualize how predicted origins and destinations would map onto the city's road network, including possible highways, San Juan's engineers adopted a method of "trip assignment" from the Michigan State Highway Department. Using basic assumptions about which routes travelers would use to get from origin to destination, they assigned trips "between subzones and stations through numbered intersections in the route network;" data to be key-punched and computed with an IBM computer (Carrill, 1952, p.410). In its attention to land use as a generator of trips, its nuanced method of distributing trip origins and destinations across the city, and in using computers to assign trips to the road network, San Juan's transportation study presaged much of the experimentation and debate to take place over the next decade. In these methods the initial stages of what would become known as "the four-step method" in travel demand forecasting are clearly evident: trip generation, trip distribution, trip assignment, and mode choice. At the time of San Juan's study, though, and for many years to come, these four steps were not so clearly delineated. In 1962, commenting on the variety of metropolitan transportation studies that had been conducted, a San Francisco Bay Area researcher would write: "There is no standard or 'cook-book' recipe for conduct and implementation of a metropolitan area transportation study. This is as it should be" (Zettel, 1962, p.3). The 1962 Federal-Aid Highway Act, mandating the 3C process, did more to standardize the four-step method than any single metropolitan study.

With the wealth of socio-economic, as well as travel data, that home interviews provided, O-D surveys saw an "invasion of the field" by sociologists, economists, and city planners and

helped bridge the gap between technical knowledge of road and highway design and behavioral understanding of urban travel patterns (Oi & Shuldiner, 1962, p.7). Together, their goal was not just to describe the complexity of travel patterns within an urban area but to explain those patterns. Engineers, city planners, and social scientists hoped to combine methods of research and analysis, including more sophisticated mathematical and statistical methods, in order to provide “a more rational and scientific basis for the planning of an urban transportation system” (Oi & Shuldiner, 1962, p.7). O-D surveys attempted to bring data and research into decision-making through analysis of travel behavior as a social as much as a technological development. This interdisciplinary collaboration was mutually beneficial: urban transportation offered to legitimize social science as science, while highway and traffic engineering benefitted from the behavioral compliment to their infrastructure repertoire.

Margy Ellin Meyerson, a sociologist at Bryn Mawr College, who followed debates in traffic engineering and city planning closely at the time, made the case for the study of transportation as a social phenomenon at the Highway Research Board annual meeting in 1955. The car in and of itself, she argued, is not alone responsible for suburbanization; rather, trends in decentralization and automobility must be understood in their social context and with an understanding of their sociological motivations. “What is the meaning of driving to the individual,” she asked (Meyerson, 1955, p.2). “We know relatively little about the shadings of meaning of car ownership, and how status strivings and aspirations are defined by different ethnic, age and geographic groups, and in addition how different personality attributes and ideological positions influence such attitudes. We also know relatively little about the status attached to various kinds of mass transportation facilities” (Meyerson, 1955, p.3-4). She called for greater social analysis of suburbanization trends and mode choice in trip-making, noting that

“transportation decisions are not based on purely economic motivations” (1955: 1). In other words, travel choices are not necessarily rational, but, like many other essentially social phenomena, both social scientists and engineers in the newly emerging field of transportation planning sought to find explanatory variables for travel behavior using statistical analysis.

Trip Generation

One of the trade magazines that Meyerson followed closely was *Traffic Quarterly*, published by the Eno Foundation beginning in 1947. A survey of the magazine’s early years reveals a fascination with traffic safety, which had been the pet project of William Phelps Enos, the foundation’s founder, and parking: Three out of seven articles in the magazine’s first issue concern parking, and for a decade, hardly an issue went by without including at least one article about parking. The problem of parking in suburban shopping centers as well as for department stores in central business districts was a real point of consternation for traffic engineers at the time and developed in parallel with ideas about land use as a generator of traffic. A study published in 1949, for example, used O-D data to analyze the power of various building types to attract traffic and create parking demand (Thompson & Stegmaier, 1949). Generation of parking demand was studied in tandem with the generation of trips, and engineers sought to formulate both as functions of employment, retail sales, and population (Hitchcock, 1953).

Robert Mitchell and Chester Rapkin, in a study by the Institute for Urban Land Use and Housing Studies at Columbia University, surveyed the field of study in the role of suburbanization and changing retail behavior in generating traffic and parking. The resulting book, *Urban Traffic: A Function of Land Use* was influential in articulating the role of land use in shaping travel patterns and vice versa. Influenced by developments in the field of sociology that sought to render qualitative observations of social phenomena into mathematical functions

for forecasting, the book's title demonstrates their desire of the times to move beyond mere description to quantified explanation; to render qualitative observations into mathematical functions for forecasting. "Explaining movement is necessary," write Mitchell and Rapkin, "if we are to progress from perception of the current phenomenon to a reasonably sound projection of its future nature" (1954, p.x). From lines of desire, they sought to derive explanatory and operational functions, and the key to explaining movement was in access to activities on the land; land uses that generated, or attracted, travel.

At the time, O-D surveys did not include questions about the types of establishments and land uses at travelers' origins and destinations. The idea that the nature of the establishment or land use could help predict trips made to it was one that Mitchell and Rapkin (1954) distilled from a number of studies in sociology, city planning, and marketing. Postwar suburbanization, along with changing patterns of consumption, challenged the historical significance of the downtown as the only destination to generate significant trip-making. Now trip-generating businesses dotted the landscape of sprawling suburbs. A number of studies, motivated as much by marketing as by traffic engineering, attempted to quantify and measure the suburbanization of social phenomena. Peter H. Rossi in an unpublished study for the Institute of Urban Land Use and Housing, analyzed "push" and "pull" factors in residential patterns, with the goal of developing predictive power. He created an index of residential mobility that served as a precursor to not only travel demand forecasting but land use forecasting, as well (cited in Mitchell & Rapkin, 1954, p.76). Exploring the relationship between workplace and residence, for example, Doug Carroll found no easy predictor of downtown workers' residences. They lived evenly across the metropolitan area. Those who worked in outlying suburbs, however, tended to reside near their workplace (Carroll, 1952). Advertising consultants conducted home

interview surveys in Fort Wayne, Indiana, in order to understand the potential exposure of drivers and their passengers to outdoor advertisements (Bureau, 1947). A 1948 study in marketing similarly explored the share of travel costs borne by consumers in the total cost of their shopping activities (cited in Mitchell & Rapkin, 1954). Attempting to model the formation and strength of retail markets across geographic space, William J. Reilly published a theory of retail competition in 1953. “Two cities attract retail trade ... from an intermediate city ... approximately in ... proportion to the populations of the two cities and in the inverse proportion to the square of the distances from these two cities to the intermediate town,” he wrote (quoted in Schmidt & Campbell, 1956, p.56). Within two years, Harry J. Casey, Jr. (1955) adapted Reilly’s model for the study of shopping and work trips in transportation planning. Because of it mimicked Newton’s Law of Gravity, the formula became known as “Reilly’s Law of Retail Gravitation.”

Concepts like gravity, taken from physics and the other natural sciences, were popular among social scientists seeking to legitimize their study of social behavior as a science in its own right. George Kingsley Zipf, for example, hypothesized that people and goods gravitated towards one another according to a uniform formula of movement: $(P1 \cdot P2)/D$, in which P1 and P2 represent two separate places and D the distance between them. He found that the amount of news reported about a city, P1, in the newspaper of a nearby city, P2, followed this formula, as did the movement of people by bus, rail, and air between 29 US cities using 1933-34 data (Zipf, 1946, p.681). Building on Zipf’s work, Stuart Carter Dodd studied the pushes and pulls of social interaction and the forces of connection responsible for phenomena such as the spread of rumors through a community, choice of friends and spouses across geographic space, migration patterns, the reputation of a firm, “telephonic interactance,” and commuting (Dodd, 1950, p.246-9).

It was from these developments in thinking about the metropolitan distribution of homes, workplaces, and shopping centers, as well as the effects of distance on social interaction, that Mitchell and Rapkin (1954) crafted their analysis of travel behavior as a function of land use. They surveyed patrons at different types of businesses in order to understand the trip-generating properties of various establishments; a department store, a specialty shop, a service establishment, and a theater. In other words, they tried to measure the respective gravity or “valence” of those establishments; the force of attraction or repulsion relative to other establishments. Based on those surveys, they developed a provisional method of modeling the distribution of urban trips between different types of establishments, or land uses. Interestingly, their example was based on pedestrian rather than vehicle trips. For example, they counted the number of establishments in each block of Philadelphia surrounding a department store, using floor area as well as distance from the store to create a profile of trip generating valence in each block. Then they posited a hypothetical formula to predict the distribution of pedestrian movements from the department store to each block, weighing the attractive force of a given block against a friction of distance factor. Comparing the hypothetical curve to actual data based on surveyed movements, they found that a combination of distance and floor space – what they called a distance-density curve – was a better predictor of movements than either density or distance alone. Mitchell and Rapkin (1954) concluded that “In terms of traffic and planning, a land use arrangement which has a variety of uses is superior to one which has segregation of uses; variety spreads the traffic burden, while segregation concentrates it” (p.175).

Drawing on his experience in Detroit, Doug Carroll led the most expensive and extensive O-D study of the 1950s. Employing 360 people over a decade beginning in 1955, the Chicago Area Transportation Study, or CATS, was the first to put Mitchell and Rapkin’s findings into

practice, including questions about establishments and land use in its home interview surveys. In 1955 the BPR summarized the significance of Carroll's previous work in Detroit and anticipated that of the Chicago study:

“A comprehensive origin and destination traffic survey of the home-interview type was completed in Detroit. The results show a need for a 259-mile freeway system, estimated to cost \$1.5 billion, to serve an estimated population of 4.4 million and its traffic by 1980. Very definite relations between trips and land use were found and these relations will aid in the conversion of future land-use forecasts into traffic forecasts. A similar origin and destination survey, estimated to cost nearly \$2 million, was started in the Chicago area. This is the largest and most costly survey of this type ever undertaken. The cost of the survey, however, will not exceed the cost of about two blocks of a Chicago expressway recently built, and is fully justified by the great magnitude of new facilities which will be based upon the results” (1955, p.30).

Costly and time-consuming research to understand the travel behavior of urban and suburban residents was seen as a worthwhile investment in infrastructure planning. Still, a lot of work had to happen between survey and plan (Holmes, 1973).

CATS explored many variables for predicting trip generation, including sales, payrolls, and number of employees, but the study team ultimately concluded that land use was easiest to relate to travel and most conducive to forecasting (Chicago Area Transportation Study, 1959, p.13). Land use also had the benefit of bringing together city planners and transportation engineers. “Transportation is so vital to land use that it may be considered an instrument for effectuating a land-use policy,” wrote Carroll, with CATS' assistant director, Roger Creighton (1957, p.7). “Conversely,” they continued, “land use so affects transportation systems that land use controls may have to be applied more rigorously to safeguard public investment in transportation facilities” (1957: 7). Not that land use data were easy to come by, though. No comprehensive database of land uses existed; they had to construct it. To do so, the CATS team divided the metropolitan study area into a grid of quarter-mile squares, inventorying land uses

within each square. To determine land use, they referenced public utility meter cards, insurance atlases, and aerial photos. Alan Pisarski worked with Doug Carroll in the early 1960s, after Carroll had moved from Chicago to work with the Connecticut-New York-New Jersey Tri-State Transportation Commission. In the absence of land use maps, Pisarski remembers field workers surveying all of Manhattan on foot (personal communication, February 14, 2013). They complemented such manual surveys with fire insurance maps, known as Sanborn maps, and advice from real estate professionals, but Doug Carroll insisted on a truly thorough survey of the urban landscape. Applying Mitchell and Rapkin's theories on a grand scale, he wanted to understand how transportation interacted with people's life cycles, their expenditures, and their culture. Land use provided critical data for understanding the motivations for trip-making. Describing the importance of land use, Carroll and Creighton (1957) wrote: "Land use generates trips to satisfy human needs; these trips flow through a network; their presence in the network shifts the relative accessibility of different parts of the urban area, in turn influencing the location of new growth, in turn forcing new transportation facilities to be built. Unless all these inter-relationships are considered, the planner is dealing with only a part of the whole, and his answers will be partial answers" (p.6). Pisarski said of Carroll's later work at the Tri-State Study: "we spent \$10 million on data collection, all of which was to verify Doug Carroll's intuition" (personal communication, February 14, 2013).

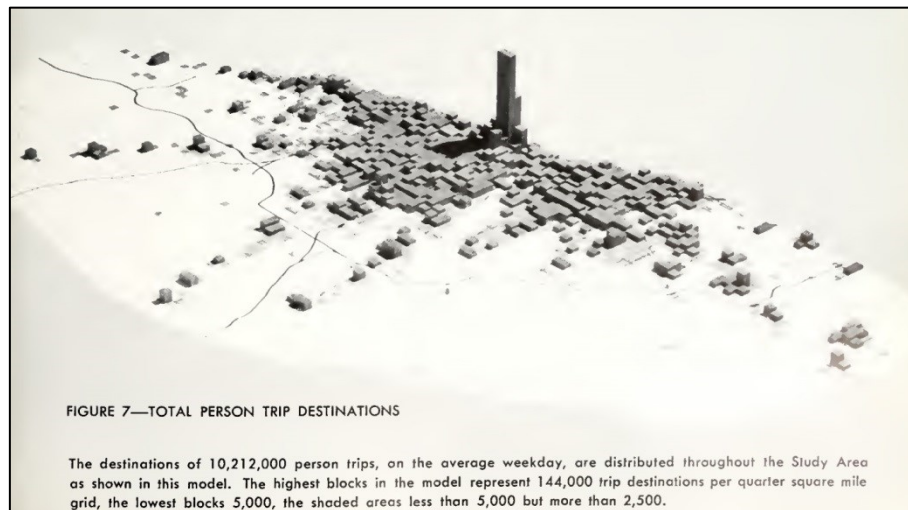


Image 5: CATS model of total person trip destinations (printed in Chicago Area Transportation Study, 1950, p.25)

On an average weekday in 1956, the study found that 10.2 million person trips and 5.9 million vehicle trips were made (Chicago Area Transportation Study, 1959, p.31). Of those, 87 percent of trips began or ended at home and around 40 percent were work-oriented (Chicago Area Transportation Study, 1959, p.33). The study team used floor area as a measure of trip generation, because floor area concentrations in the downtown Loop matched trips destined for that area. The correlation was seen as confirmation of Mitchell and Rapkin’s hypothesis that travel is a function of land use. Similarly, less dense concentrations of floor area in Chicago’s suburbs correlated with fewer trips to those areas. “These residential and nonresidential floor area models are excellent indexes of the kinds and density of human activities taking place at locations within the Chicago area,” the study concluded. “Since people are the active agents in generating travel, these floor area facts are tapping and measuring the basic underlying cause of traffic patterns” (1959, p.27). They calculated trip generation rates by dividing the number of trip destinations to a land use by its area. In doing so, they found that residential, manufacturing, and public building lands all generated trips at about 31,000 per square mile, while commercial land generated trips at four times that rate, or 116,000 (Chicago Area Transportation Study,

1959, p.58). This finding, they concluded, “identifies commercial land as being most likely to have a greater potential for traffic congestion, parking and other transportation problems” (Chicago Area Transportation Study, 1959, p.58). This finding appears to justify traffic engineers’ focus on parking and shopping habits in their exploration of urban travel.

CATS was at the cutting edge in its use of computers to analyze and visualize data. The study developed an elaborate method of mapping desire lines, for example, using a custom-built Cartographatron that joined a computer with a cathode ray

tube and camera. Origin and destination data on trips were recorded on tapes to be read by the Cartographatron’s computer element, which then drew lines representing trips across the face of a cathode ray tube. A camera focused on the tube recorded the emerging lines of desire on a continuously exposed negative. The resulting image looks like an x-ray of the city, in which white desire lines make up the skeleton of a fleshier urban form. Once data had been collected and

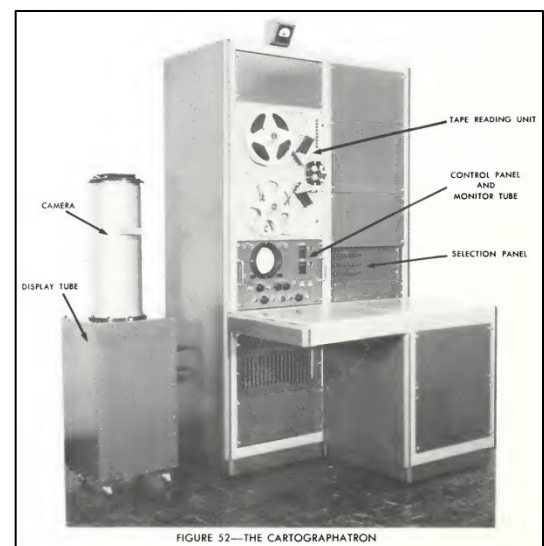


Image 6: The Chicago Area Transportation Study’s Cartographatron (printed in Chicago Area Transportation Study, 1959, p.98)

visualized, the challenge remained of how to forecast future trends. How to use a model of existing travel patterns to estimate future patterns? The study team determined, as in San Juan, that trend lines could not predict accurately. Dynamic growth would surely defy linearity. Carroll argued that O-D data for existing travel patterns could not forecast future land use and trip-making relationships; O-D data should be used to determine the “means of projection” rather than the projection itself (Carroll, 1957, p.680).

Trip Distribution

In order to model the distribution of trip origins and destinations across the metropolitan area, CATS took inspiration from the work of Reilly, Zipf, and other sociologists, as well as Mitchell and Rapkin. In their work on the earlier Detroit Metropolitan Area Transportation Study, Carroll and his team had projected land use and travel behavior in 1980 using 1953 O-D data (Carroll, 1957, p.680).

To distribute origins and destinations, the Detroit team developed a rudimentary form of intervening opportunities

model, building on work by Thomas Fratar. Working on an origin and destination study in Cleveland, Fratar had improved on methods of modeling the distribution of interzonal traffic.

Up to that point, cities had simply calculated a uniform growth factor across all interzonal transfers, assuming uniform growth across the urban area. The application of such factors was particularly insensitive to undeveloped land with development potential (as multiplying zero trips by any growth factor still predicts zero trips). San Juan's study had added some nuance to this technique, customizing growth factors customized for each interzonal transfer. Working in Cleveland, Fratar (1954) observed that the distribution of trip origins and destinations among various land uses was relative, while planners would be hard pressed to be able to intuit how development could affect the distribution of future trip-making. "Changes in the relative attractiveness of any interzonal movement," he wrote, "will result from changes in the traffic generated by the two zones involved relative to change in the traffic generation of other zones" (1954, p.376). Imagining twenty years into the future, he wrote, "people will have to go to and



Image 7: Desire lines for all vehicles in Chicago, produced by the Cartographatron of CATS (printed in Chicago Area Transportation Study, 1950, p.55)

from work, to and from shopping, and so forth, in about the same way as they do now. A difference will be that there will be more people, more shopping areas, and more places to work” (Fratat, 1954, p.377). He wondered what the new distribution of trips would be.

As an answer to this question, he offered a method that accounted for the relational nature of trip-making while also attempting to minimize arbitrariness in necessary adjustments: distributing origins and destinations by successive approximation involved averaging the origins and destinations of each pair of zones iteratively until the distribution of interzonal transfers evened out (Fratat, 1954). George Wickstrom recalls using this “Fratat method” in New York City in the early 1950s (personal communication, March 6, 2013). He was working as a traffic engineer for the city, which was planning the Verrazano-Narrows Bridge between Brooklyn and Staten Island, along with an underground subway tunnel. Both the city and the Port Authority did their own data collection and modeling for the bridge. Then they met and compared results, which were identical. Together, the two agencies moved forward with the bridge and tunnel (Wickstrom, personal communication, March 6, 2013).

Detroit’s distribution model differed from Fratat’s in its attempt to incorporate some of the sociological thinking on gravity, or valence, as Mitchell and Rapkin had called it. The idea was not just abstract growth factors, however attuned to the particular mix of land uses in any given analysis zone, but a mathematical model that accounted for the relative attractive force of a zone’s unique mix of uses and development, as well as the friction or hindrance of distance. Carroll (1957) described the model in terms of “intervening opportunities,” a phrase taken directly from the work of the sociologist Samuel Stouffer. Stouffer, a contemporary of Zipf and Dodd, had developed his intervening opportunities model to relate the mobility of migrants to the

distance they traveled in migration. Morton Schneider developed the intervening opportunities model further at CATS. A 1962 BPR report describes the model in this way:

“The opportunity model distributes trips on the theory that each zone has a stated probability of being acceptable as a destination for work, shopping, etc., and that people want their trips to be as short as possible. The probability that a zone is acceptable is proportional to the size of the zone and inversely proportional to the trips which have not yet found a desired destination. The competing-opportunities model theorizes that only zones within specified time limits of travel compete for trips from all other zones, and these zones compete in accordance with the size of the zone” (Bureau of Public Roads, 1962, p.36).

Rooted in Carroll’s deep focus on data collection and the sociology of urban travel, Schneider was interested in developing models that reflected human psychology and expressed reservations about likening such behavioral analysis to science, per se. He thought gravity was an unfortunate analogy for describing the attraction of land uses for trips, for example, because gravity does not describe intentions (Schneider, 1959). Schneider also wrote about the inadequacy of thinking in terms of zonal transfers but acknowledged that analysis zones would probably persist by sheer force of habit (Schneider, 1959). The intervening opportunities model, more than the growth factor and Fratar methods before it, sought to reflect the social fact that people make trips to access certain goods and activities.

Alan Voorhees, as a graduate student at Yale before he joined the Auto Safety Foundation and helped organize the National Committee on Urban Transportation, wrote his thesis in response to the “so-called land use approach” of modeling trip distribution. As an alternative, he offered his own “general theory of traffic movement” in a paper that won the Past Presidents Award of the Institute of Traffic Engineers (Voorhees, 1956). Responding to an article in which Fratar described his own method, Voorhees argued that distance mattered more than land use, per se, in the distribution of trip origins and destinations (Fratar, 1954). Impedance, in other words, was more significant in determining people’s travel behavior than

their desire. Fratar (1954) respectfully disagreed, writing that distance alone was meaningless, since preferences for trip-making (including distance) were reflected in the data itself.

Voorhees was primarily interested in estimating future travel to new developments, such as suburban shopping centers. The 1950s saw the growth of supermarkets as a replacement for neighborhood corner markets, which increased driving. Voorhees (1956), responding to Mitchell and Rapkin (1954), as well as Fratar (1954) and Schneider (1959), used Reilly's Law in his general theory of traffic movement. His model differed from the Fratar method, as well as Schneider's intervening opportunities model in that it relied on distance in the denominator, rather than relying on relationships of origins and destinations to the potential of alternatives. Voorhees was anything but prolific, and his writing is awkward, but where he lacked in written communication skills he made up for in interpersonal skills. No one doubted his intelligence, so he was very persuasive, and improved versions of his gravity model are ubiquitous today.

At the time he wrote his thesis, though, the model was only hypothetical, and it remained un-tested for several years. One of his first opportunities to test the model was in Frankfurt, Kentucky, where the firm of Hammer and Associates hired him to work on a contract for the capital city of 35,000 (Siler, personal communication, November 1, 2012). Voorhees knew what he was doing, though, according to Bob Siler, then a recent graduate of UNC Chapel Hill's City Planning program working for Hammer's firm. For Voorhees, the city offered a test site with which to prove his method's applicability. "He was more interested in the research potential of the project than he was in being remunerated for it," remembers Siler (personal communication, November 1, 2012). They used the Kentucky River, which flowed through the city, as a screen-line to study traffic moving east and west across a single bridge downtown. They divided the city into analysis zones and compiled data on employment and population, as well as traffic

flows, by zone. Then Siler met Voorhees in Washington at the offices of the Auto Safety Foundation, where they spent a long weekend holed up with two Monroe calculators. “We ran numbers until they were coming out of our ears,” remembers Siler; they calculated the hypothetical traffic flows across the bridge and then compared them to the actual observed numbers, and the model worked (personal communication, November 1, 2012). From there, they forecasted traffic twenty years into the future and translated the forecasts into a conceptual plan.

Trip Assignment

Origin and destination surveys gave a sense of ‘travel desires’ in an urban area: connecting origins to destinations created a schematic map of travel patterns to inform decision-making, but such desire line maps did not connect trips to the actual road network, whether existing or proposed. The first efforts to assign or distribute¹ trip data to the road network considered one road at a time and offered a rudimentary method of forecasting future travel on a proposed road. Systematic trip assignment across an entire metropolitan road network was little more than an aspiration until computers made large-scale data analysis possible.

The Highway Research Board (HRB), established in 1920 and now known as the Transportation Research Board (TRB), facilitated information exchange about highway engineering and began to participate more actively in urban transportation studies in the 1950s (The Transportation Research Board, n.d.). Engineers at the HRB were instrumental in fostering innovation in trip assignment techniques, for example. An HRB publication of 1950 begins by saying: “The analyst of origin and destination interviews is yet an explorer of uncharted areas in

¹ Though this particular technique has become known as ‘trip assignment,’ the terms assignment and distribution were used interchangeably at the time.

human behavior” (Campbell, 1950, p.i). The problem of how to turn origin and destination data into models of actual trip-making across an urban area was one that M. Earl Campbell had been thinking about at the HRB ever since O-D data began to pour in from cities across the country. In order to assign hypothetical trips to the road network, Campbell needed a way of measuring and relating the variables that influence travel behavior; a driver’s choice of route, for example. He surveyed O-D reports from across the country to see what, if anything, cities were doing to assign O-D data to the road network (Campbell, 1950). He found that engineers used time or distance, and sometimes both, along with a healthy dose of judgment in routing trips in their models. Nobody had yet found a satisfactory formula to give numerical weight to the various factors involved in determining a traveler’s route choice. Engineers in Ohio, for example, reported that they would assign origins and destinations to the road network by “average[ing] the individual judgment of 3 men, considering factors of street pattern, condition, terrain, attractiveness, hazards, etc.” The result of such an averaging of judgment, furthermore, was likely to be “25 percent or 30 percent in error” (Campbell, 1950, p.3).

What was it that guided decision-making in travel? Distance was obviously important. If a new expressway was longer than any other existing street, then nobody would have a reason to abandon the existing roads. Of course, time mattered, as well. A new expressway might provide a longer route than existing streets, but if vehicles on it could drive faster, then it could help distribute traffic across a broader swath of road infrastructure. At the same time, Campbell and others recognized that a number of more difficult-to-measure variables were also in play; this was, after all, human behavior. Feeling unsatisfied with his survey of O-D reports, Campbell (1950) drafted an S-shaped diversion curve to illustrate the trade-off between travel along an existing route and potential diversion onto a new one. The curve remained hypothetical, though;

the crucial question confronting Campbell was how to weight the points between zero diversion and total diversion, and, in particular, how to estimate the point at the center of the S, where use of existing streets would tip over to diversion onto a new facility.

Campbell (1950) sent the schematic curve, with an explanatory letter, to highway departments in every state for input and feedback. The resulting correspondence reveals a widespread curiosity about the optimization of transportation infrastructure, as well as the unevenness of knowledge and resources across the states. Some responded with very sophisticated explanations of their own methods and thought processes, while others simply congratulated Campbell on his logic and confessed not to have anything to add. An anecdote from an Arkansas engineer helps to illustrate the simple but confounding problem that seemed to stand in the way of truly rational transportation planning. Of Little Rock, he wrote: “We have within two blocks of the Capitol two parallel streets a block apart. One carries traffic at a point nearby of 15,000 vehicles per day and the other carries less than 5,000 vehicles per day. The less traveled street is wider and for the most part smoother but there are four blocks where there are old street car tracks and the distance of the four blocks is the only reason that I have been able to discover to cause motorists to use the more congested streets” (Campbell, 1950, p.46).

Campbell and others recognized that the question of why people choose the routes that they do is, in many ways, inseparable from the question of what they hope to do at their destination, as well as why they choose the mode of transportation that they do for any given trip. In addition to observations such as the one from Little Rock, O-D data had revealed travel behavior to be varied, complex, and contextual. Even if the relevant variables could be settled on and weighted properly, surely they would need to be weighted differently for different populations, trip purposes, and modes of travel. For example, Campbell recommended that

distance receive more weight in poorer areas, where residents would likely be more conscious of vehicle operating costs (Campbell, 1950). A number of “intangible” variables also posed a challenge to mathematical formulation. Beauty, comfort, habit, safety, tension, “investigative desire,” and “a desire for unremittent motion,” were all such intangible variables that emerge in Campbell’s correspondence with state highway engineers (1950, p.i,7).

Campbell’s interest was on a road-by-road basis and he was not too concerned with the long-range consequences of infrastructure improvements. “Since expressways are built to relieve pressures at the present time,” he wrote, “we need not be concerned too much about relative volume adjustment 20 years from now, except to provide a sufficiency in expressway design capacity. We are immediately concerned with relief during the critical hours of today’s traffic” (1950, p.8). Several state highway engineers responded in disagreement with this comment, though, and Campbell was moved to accept their vision of transportation planning for the *longue duree*.

Some of the state highway engineers emphasized time as the most important determinant of drivers’ route choices. Drivers don’t think about operating costs, argued one engineer from Kansas, and because they don’t think about operating costs, they aren’t conscious of the total cost of each trip they make, a combination of operating costs and time. Time, he wrote, “is the essence of our industrial mass production efficiency. The everyday life of the average American is geared to time” (Campbell, 1950, p.55). Other states’ highway engineers agreed. Engineers from Washington were so focused on time that they thought it wasteful to try to analyze anything else. “An area divided into 100 zones ... would have 10,000 possible trip movements,” they wrote, “and to examine each movement (qualifying for assignment) in connection with all the factors that influence a decision (distance, time, economy, convenience, comfort, beauty, etc.)

would not only be extremely difficult but unjustified” (Campbell, 1950, p.44). Time, to Campbell, was the most important factor because, “[t]o go into further refinement would be somewhat questionable” (1950, p.44).

The director of Maryland’s State Roads Commission wrote to say that while time and distance (time being paramount), were the most important variables to study, such factors were still insufficient. “The real ‘guesstimate,’” he wrote, “is that of induced traffic, which seems to just come from nowhere. It has been our experience in checking estimates of traffic potential to a facility after it is opened that the estimates usually are lower than the actual counts upon completion” (Campbell, 1950, p.16). New methods were needed. Connecticut’s State Highway Commissioner suggested increasing Campbell’s allowance for intangibles. The question for him was deciding which factors should be included in the diversion formula and how to measure them – factors such as time, distance, speed, comfort, scenic and other attractions, vertical and horizontal alignment, avoidance of stops, safety, etc.

Ted Holmes, Chief of the BPR, wrote in measured terms to say that the Bureau didn’t have anything with which to refute Campbell’s schematic. Nor did they have much with which to support it, though. What was most needed, in his view, were case studies with which to test various proposed methods (Campbell, 1950, p.52). Holmes supported research and experimentation in various cities and through research institutions. Throughout the era, the Bureau was an engine of research and exchange. In addition to conducting and encouraging research, engineers at the BPR taught what they learned and created tools for transportation planning efforts. Through the 1960s, “the BPR was like a school,” according to Kevin Heanue (personal communication, January 17, 2013), who made his career in the Bureau, which was part of the Department of Commerce until 1966, after which it was renamed the Federal Highway

Administration (FHWA) and relocated in the newly formed US Department of Transportation. It printed manuals and offered courses to metropolitan planners and engineers, as well as elected officials and international visitors. Everyone in the Bureau did research, too, according to Heanue. Everyone had to present at the annual HRB meeting. As another career FHWA engineer said, “the feds didn’t ask the cities to do anything they couldn’t tell them how to do” (Weiner, personal communication, January 16, 2013).

A California Division of Highways engineer responded to Campbell’s letter with perhaps the most sophisticated knowledge and experience of analyzing O-D data. The letter provides a lucid critique of Campbell’s proposal that analysis and planning should address the peak hours of congestion. Rather, the California engineer argued that new roads should be planned according to average daily traffic, assuming that peak hour travel would be 12-16 percent higher than average (Campbell, 1950, p.50). He also outlined the Division’s improved method of mapping origins and destinations by areas of contour rather than desire lines.

This correspondence offers a view into the state of a newly emerging practice; specifically, techniques of what became known as trip assignment in travel demand forecasting. In 1952, the American Association of State Highway Officials (AASHO) published an S-shaped diversion curve for trip assignment that became a standard in cities for years to come (Weiner, 1999, p.23). Still, the discussion played out in Campbell’s correspondence with state highway engineers would not be quickly resolved. With Robert Schmidt, Campbell published *Highway Traffic Estimation* in 1956, published by the Eno Foundation. An important compilation of research and methods developed to date, the book is more technical than the National Committee’s *Better Transportation in Your City*. Geared to highway engineers more than elected officials, Schmidt and Campbell’s book emphasizes the need for a universal nomenclature; a

language with which to communicate transportation. Accordingly, they offer definitions to distinguish between concepts of diverted, converted, potential, induced, generated, and translated traffic. The fact that some of their definitions would soon become obsolete indexes the extent to which methods and their language were in flux. Schmidt and Campbell (1956), extending the discussion of trip assignment that Campbell had initiated with state highway engineers, refer to the technique as “distribution,” for example. In hindsight, it is also curious the extent to which Campbell’s correspondence with state highway engineers lacks any mention of the activities for which people make trips. Theirs is a conversation about mapping routes, not about motivations for travel. As the correspondence indicates, though, it is difficult to route trips in the abstract without some understanding of the motivations for travel.

Computers

In the evolution of O-D surveys to forecasts and then plans, advances in computing technology played an important role. Trip distribution and assignment would have been unthinkable without computers, which allowed engineers to simulate the road network and its future travel demands. Simulations also allowed for testing various possible plans; to see the effects of different facility improvements on the network. Computer programs allowed engineers to model current patterns, as well as their future developments, and methods of transportation planning developed in tandem with technological advance: available technology influenced the development of methods, and the development of methods spurred innovative use of new technologies. Models were not new to engineering, but their use for solving broad operational problems was (Howland & Vaswani, 1958). Computer modeling allowed engineers

to see the road network as a whole, in simpler form; to control some variables and see the effects on others.

Before computers were used to model traffic flows throughout a network, though, traffic engineers used computer programs for traffic control, to create signalization schemes (LaVallee, 1956). Making the leap from signal circuits to flows of people and vehicles required assistance from other fields in quantifying behavioral variables. The study of travel as a function of land use would not have been possible without computers, according to Ted Holmes (1973), “but the application of the new technology could not have been implemented without converting the land-use inventories and projections from a qualitative to a quantitative basis and bringing into the planning process, up until then carried on largely by engineers, professionals from other disciplines who were better equipped by training to deal with the factors of land use and urban growth” (p.382).

The development of linear programming in the newly developing field of operations analysis took inspiration from economics, geography, as well as engineering. It was linear programming, with its roots in economic cost and benefit analysis and goals of system efficiency that moved traffic computer programs into the realm of systems analysis. Garrison, et al. (1958) sought to apply economics and location theory to road networks; using linear programming to study the costs and benefits of highways as a network. Howland and Vaswani (1958) similarly outlined the applicability of operations research to transportation planning, offering the developing field of scientific decision-making as “a procedure for dealing with the broad social and economic framework of technical problems” (p.72). One of the first applications of linear programming to a transportation problem was a study for the New York Port Authority to optimize the work schedules of toll collectors (Howland & Vaswani, 1958).

As O-D surveys evolved into more comprehensive transportation studies and computers became the primary means of analyzing O-D data, the BPR cultivated a library of computer programs collected from cities, states, and universities. The Bureau's 1957 annual report cites 35 state highway departments that were then using electronic computers to analyze O-D data. In its 1960 annual report, the Bureau notes that the cities of Washington, Columbus, Minneapolis-St. Paul, El Paso, Topeka, and Nashville had used its program for trip assignment. "In addition to determining the probable traffic volumes on proposed new facilities," the report notes, "planning agencies were finding that the assignment program is a useful tool in selecting the locations of new facilities" (Bureau of Public Roads, 1960, p.51). In other words, it took some time for the modeling programs to be used for siting new facilities.

Computers also lent weight to traffic engineers in speaking to communities about new highway plans. Tom Deen, working in Nashville, remembers computer results making for powerful public presentations: "the data that came out of the computer was almost sacred and there was no dispute about it" he said (personal communication, October 20, 2012). Computers also had their limitations, though, and a story from the Tri-State study in the early 1960s serves to illustrate their fallibility. Alan Pisarski remembers walking into the Tri-State Study's office one day, only to be told that there was "big trouble downstairs" (personal communication, April 12, 2012). The office was located at 100 Church Street in lower Manhattan, right next to the World Trade Center, which was under construction at the time. The expansive basement was not only underground but below sea level and was home to the land use data collection unit, which, at that point, had collected data on every parcel of land in the region. The data had been keypunched: one card per parcel. The land use unit had organized the "then called" IBM cards into some three thousand boxes, at two thousand cards a pop. These they had stacked in a wall

to divide space within the room. It was five feet tall and forty feet long. On the day Pisarski was told there was trouble downstairs, there had been a storm the previous night. Water seeped into the room and soaked the bottom layer of boxes. As he walked in, twenty staff members were trying to hold the wall of boxes in place as it stood swaying and wobbling from the saturation of its foundation. Doug Carroll, a taciturn man, was known to say thereafter: “That’s what you call a truncated data set” (Garrison, personal communication, November 14, 2012).

Modal Split

While O-D studies in metropolitan areas had included transit operations, it was not until the 1960s that engineers found a way to incorporate modal split into the models themselves. Public transit’s fate in American cities was somewhat indeterminate, if overshadowed by cars and the highways needed to move them. Transit systems – mostly buses, streetcars, and some light rail and subways – suffered neglect during World War II, even as their ridership spiked. For much of the war years, it was even considered un-American to buy a new car or drive one for fun. The postwar years saw a release of pent up demand; nearly everyone who could buy a car did, and those who couldn’t, aspired to. Transit seemed antiquated, and by then, its infrastructure was in serious decline, without money for revitalization. While cars were in vogue, though, and federal funding favored highways, transportation studies recognized transit as an important element in understanding movement in cities. Some even saw highways as a benefit to transit service; many highway plans envisioned bus-only lanes or light rail sharing the highway corridor. As a 1944 manual noted, “Since the streets and highways serve alike for both individual and mass transportation, they must be planned with a knowledge of the overall transportation requirements if we are to remedy the chaotic conditions which now exist in many

of our metropolitan areas” (Public Administration Service, 1957, p.2). Engineers recognized that transit carried many of the trips in urban areas and, especially, in large cities. What role did mode play in determining travelers’ choices, though?

Toronto was the first city to incorporate modal split into its demand forecasting models. Having managed to save money during the war, the Toronto Transit Commission built its first subway line in 1954 (Irwin, personal communication, April 6, 2013). A newly formed Metropolitan government, established the year before, was also well-suited to tackle urban issues like transportation infrastructure on a metropolitan scale; the original municipalities of metropolitan Toronto maintained fewer functions under the new Metro government (kind of like the boroughs of New York City), and the Metro government controlled all the major streets and roadways, as well as the Toronto Transit Commission. The government hired a newly formed transportation consulting firm, the Traffic Research Corporation, which quickly sold the government on the idea of computer controlled traffic signals (Irwin, personal communication, April 6, 2013).

Daniel Brand studied transportation planning at MIT and graduated in 1961, having completed his thesis on computer controlled traffic. He took a job with the Traffic Research Corporation (TRC) to work on forecasting demand for highways and subway lines in metro Toronto. Neal Irwin was his boss and remembers that the idea of incorporating modal split into their demand models became apparent in the course of their work. As with other first stabs at modeling travel, engineers at TRC first resorted to empirical observation in hopes of getting to an explanatory theory of prediction (Brand, personal communication, April 2, 2013). Their first effort was what Irwin called an “honest engineering approach” (personal communication, April 6, 2013). They created a diversion curve, an S-curve that they calibrated by observations from

O-D data with ratios on each axis; a combination of in-vehicle time and out-of-vehicle transit time on the x-axis, and modal split on the y-axis, each stratified by cost and time. At the time the technique was binary; splitting trips between auto travel and all of transit, lumped together. They used current subway ridership, in addition to bus ridership, to forecast demand on additional subway lines.

Eight months after Brand moved to Toronto, he and Irwin went to Washington, DC, where the National Capital Transportation Agency (NCTA) had hired TRC to plan a subway system for the city. There, Tom Deen was working as Technical Director. He had moved to Washington shortly after leaving Nashville, the third staff person hired onto the NCTA, of which he would later become Director. Working with the NCTA, Deen befriended Lee Mertz, a veteran of the Tri-State Transportation Study with Doug Carroll, who was hired to work for the new Washington Council of Governments (WashCog) and plan highways for the capital city. Deen and Mertz decided to work together in planning transit and highway infrastructure. To the consternation of their superiors, they agreed to carry out joint forecasts. Their goal was to limit debate to interpretation of the numbers rather than the numbers themselves. “It caused great eyebrow raising on the part of the director of the NCTA, because he thought I was selling out to the highway interests to work with the highway people,” said Deen, “and the highway people were worried about Mertz working with me” (personal communication, October 20, 2012).

Brand and Irwin used the methods and curves they had developed in Toronto and calibrated them with Washington data. They had only bus ridership numbers with which to estimate potential subway ridership. Brand remembers working eight hours a day on I Street, followed by eight hours at night in the basement of the National Bureau of Standards on Connecticut Avenue, where TRC rented computer time (personal communication, April 2,

2013). In addition to travel time and cost, the models used income to predict how many trips people would make by transit and private auto. Travel time and cost included the time and cost of accessing transit. Brand remembers a moment of revelation he shared with Deen when, looking at the results of their analysis, they realized that the impact of one minute of out-of-vehicle time was equivalent to two to three minutes of in-vehicle time. People do not like to have to walk very far or wait very long to access transit.

The joint efforts of NCTA and WashCog produced plans for an extensive subway system, as well as a network of highways smaller in scope than had previously been imagined. “We recommended killing a number of roads that were being planned,” says Deen, “which was almost sacrilege” (personal communication, October 20, 2012). The Road Gang was not pleased. An informal lunch gathering of transportation officials (Swift, 2011, p.307), the Road Gang was headed by Frank Turner at the time, who invited Deen to talk to the group. “While highway interests would give lip service to transit, the idea of spending big bucks [on transit] when highways were clearly the answer to the future didn’t sit well,” said Deen of people like Turner. “He [Turner] was not happy, and that organization was not happy about what I had to say, but [our ideas] would be much more acceptable today. Highways were a good thing. Frankly, I wondered myself whether we were doing the right thing, but our recommendations stuck. Roads are not an unmitigated good” (Deen, personal communication, October 20, 2012).

The Three C's of Metropolitan Transportation Planning

By the time Deen and Mertz were working together to incorporate both highways and transit into a comprehensive plan for the national capital, transportation planning had come into its own as a field of practice. In the BPR's annual report of 1962, the culmination of a decade of experimentation and innovation is apparent:

“Public Roads’ urban planning research during the year was directed toward the continuing development of basic data, techniques, and procedures for a rational process of comprehensive urban transportation planning, in particular those related to estimating the future travel demands of our increasing urban population. Carrying out these functions will require the development and improvement of data-collecting and planning techniques through the application of modern statistical methods, full utilization of high-speed data processing equipment, and the design, testing, and use of mathematical models wherever possible” (p.36).

The 1962 report goes on to acknowledge the important role of interdisciplinary cooperation in the development of rational planning methods, calling for continued collaboration and the consolidation of highway engineering with city planning: “The introduction of new engineering skills and of disciplines not heretofore generally associated with transportation – for example, that of the geographer and the sociologist – as well as that of the economist and planner, will be needed. The gap between the conceptual approach of the city and metropolitan area planners and the quantitative approach of the highway planner must be bridged” (Bureau of Public Roads, 1962, p.36). If 1956 marked urban areas’ claim on federal highway funds previously concentrated in rural areas, then 1962 marked the transformation of highway funding into comprehensive transportation planning as advocated by Ben West and so many other urban advocates around the country.

While large cities like Detroit, Chicago, Philadelphia, and New York, along with some innovative smaller cities, had advanced forecasting methods, the majority of American cities, and especially smaller ones, were ill equipped to learn and implement such techniques. In

January 1962, in Kansas City, the National Committee on Urban Transportation adopted an Action Program to continue its efforts to educate city officials and civil engineers in the methods of metropolitan transportation planning (Holmes, 1973). The Action Program called for a series of regional meetings to which all state highway departments and all cities would be invited and where the methods of comprehensive metropolitan transportation planning honed over the course of the last decade would be explained (Holmes, 1973). In April of 1962, President Kennedy spoke before Congress about the need for comprehensive urban transportation planning. The national welfare, he said, “requires the provision of good urban transportation, with the properly balanced use of private vehicles and modern mass transport to help shape as well as serve urban growth” (The transportation system of our nation, 1962). In addition to proposing funding schemes for mass transit projects under the Housing Administration, Kennedy talked about transportation plans as a necessary component of urban development: Highways, he said,

“are an instrumental part of any coordinated urban transportation program, and must be an integral part of any comprehensive community development plan. Accordingly, I have requested the Secretary of Commerce to make his approval of the use of highway planning funds in metropolitan planning studies contingent upon the establishment of a continuing and comprehensive planning process. This process should, to the maximum extent feasible, include all of the interdependent parts of the metropolitan or other urban area, all agencies and jurisdictions involved, and all forms of transportation, and should be closely coordinated with policymaking and program administration” (The transportation system of our nation, 1962).

Congress passed the 1962 Federal-Aid Highway Act later that year, mandating the “3C process” for federal highway funding.

In May, the National Committee convened its first regional meeting of the Action Program in Chicago. Over the course of the next year, over 1,500 state and local officials participated in its programs, many having their first exposure to the idea of metropolitan

transportation planning. Ted Holmes, Director of the BPR, wrote later about the 1962 Act as an affirmation of the National Committee's work with cities across the country. "Those of us engaged in promoting planning through the Action Program liked to regard the 1962 Act not as a new congressionally conceived requirement," he wrote, "but rather as an endorsement of a process already proving effective in many areas" (Holmes, 1973, p.387). It was also to the National Committee that the BPR turned for translating the 1962 Act's 3C mandate into operational terms. After a series of consultations with the National Committee, the BPR published Instructional Memorandum (50-2-63) in March 1963, detailing the methods of travel demand forecasting necessary to meet the 3C mandate of the Act's Section 9, later revised as Section 134 of Title 23 (Holmes, 1973).

Conclusion: The Transportation Problem, Revisited

The work of the National Committee on Urban Transportation, the BPR, and all of the many metropolitan and other studies carried out throughout the 1950s, offered a wealth of experience on which new metropolitan area studies would draw to meet the 1962 Act's 3C mandate. The Bay Area Transportation Study Commission (BATSC), in a 1964 report on the status of its Bay Area Rapid Transit (BART) planning, for example, was able to summarize over a decade of research and experimentation in a neat description of *the* urban transportation study:

"In its simplest format, the procedural steps of a comprehensive urban transportation study follow a logical sequence: from basic inventories to analysis to forecasting to planning. The basic premise of the transportation study is that there is regularity and rhythm in the daily lives of large numbers of people, such that systematic patterns in their personal travel (and in the movements of their goods and services) can be discovered through the collection and analysis of data. Once established, these patterns can be simulated in mathematical expressions or

models and projected into the future according to the expected future development of the area, thus providing reasonable forecasts of future travel patterns. Such forecasts would provide a basis for designing a transportation system to meet the demand” (p.3-4).

Such streamlining of the planning process borders on simplification, though, and, in fact, BATSC eschewed innovation in order to meet the 1962 Act’s deadline for funding. Continues the report, “the Commission must adhere to a rigid time schedule if it is to discharge its responsibilities to produce a regional transportation plan within the time intended by the Legislature. Time cannot be squandered on experimentation. Thus all experimental work to be done will be back-stopped by established methodology which has proved to be effective, if not conceptually ideal” (Bay Area Transportation Study Commission, 1964, p.18).

In marked contrast to earlier metropolitan studies, the BATSC authors wrote with a federal deadline for funding in mind. Many cities scrambled to meet the Act’s 1965 deadline for completion of all transportation studies. What began as a comprehensive effort to make transportation planning more scientific and less susceptible to the arbitrariness of politics and personal judgment, and that benefitted from streams of highway funding to urban areas provided by the 1956 Federal-Aid Highway Act, had already begun to be reduced to an instrument of financial advantage by 1965. Later critics would point to the ways in which transportation forecasts overestimate use and underestimate costs and how their products are susceptible to manipulation for pre-conceived political ends (Wachs, 1987, 1990; Flyvberg, 2007; Flyvberg & Molley, 2011). But such critiques rely on a reduction of the forecasting process, as well as an extraction of forecasting from the broader context of research and planning. Such a division, as I have shown here, is noticeably absent in the early development of forecasting methods, which were indivisible from planning as such.

Writing as early as 1970, Roger Creighton, who worked as assistant director of CATS under Doug Carroll, commented on the danger of reducing transportation models and of misunderstanding their value. What transportation planning – synonymous with demand forecasting, in his view – offers is a certain consciousness. Echoing early studies in travel behavior and origin and destination analysis, he describes transportation planning as “a venture – one might almost say an adventure – to be more far-seeing, more comprehending, and better able to deal with complex problems” (Creighton, 1970, p.xviii). As a venture, the technical methods of forecasting attempt to see a city whole and better inform decision-making. The complexity of cities makes it impossible to understand them through “conventional thinking and conventional planning,” he wrote (1970, p.xxiv). Conventional thinking breaks the city down into component parts, categories, and classifications, but “when we measure cities and urban travel, we see (if our measures are fine enough) that this world does not work in categories but in continua” (Creighton, 1970, p.xxiv). There is no meaningful distinction between city and suburb, for example: “even the term ‘city’ becomes a false classification” (Creighton, 1970, p.xxiv). To him, the methods of transportation modeling offered a kind of calculus to deal with the change and continua of urban reality, in place of the simple geometry or algebra of conventional thinking (Creighton, 1970). He rejects the illusion of simple solutions. “The direct implication of dealing with a continuously varying subject is that there can be no simple answers or categorical solutions to transportation planning problems” (Creighton, 1970, p.xxv).

Keith Gilbert, who worked on the National Committee pilot project in San Diego in the 1950s, echoed a similar point. Modeling does not necessarily *work*, he said; models require calibration, recalibration, and many adjustments: “factors for this and factors for that, to make it fit what’s on the ground” (personal communication, March 7, 2013). In the decision-making

process for infrastructure plans, though, such model idiosyncrasies are not as problematic as the misinterpretation of their capacities; “We’re talking about the movement of people, about how people live,” said Gilbert. “It’s not an engineering problem. It’s a social problem” (Gilbert, personal communication, March 7, 2013). Perhaps the 1962 Federal-Aid Highway Act’s mandate for travel demand forecasting reduced modeling, in practice, from a process to a product. Such reduction allows the methods to be both dismissed and manipulated.

What this history demonstrates is that the true benefits of forecasting in the 1950s were not realized in the forecasts themselves. Many of them were wildly off the mark. Some produced bizarre plans that were never constructed. But the process of experimentation in data collection, analysis, and cooperative decision-making offered a new understanding of urban travel that could not be easily un-learned by anyone involved. Creighton, already responding to the abstraction of modeling from planning in 1970, warned about the dangers of taking lessons learned in previous studies as rules to be applied uncritically: “A principle, in the sense of being ‘a settled course of action’ (Webster) or a settled manner of design, is derived from a chain or process of reasoning, of which the principle is merely the short-hand statement of conclusion. Quite obviously, principles are unworthy guides for action to the person who does not know the background reasoning” (p.229). Principles, like models, obscure as much as they illuminate in their distillation of complex phenomena. But such distillation should also not be taken as simplification. As Creighton wrote, “Two-dimensional reasoning, thrust into an n-dimensional world, must often be upset” (Creighton, 1970, p.229).

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